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## Optimal Diameter for the Ring of Bristles in a Golf Tee

(The following calculations are based on an idealised situation, and should be regarded as only an approximation to reality.)

The variables required in the calculations are:

$a$  = radius of golf ball (taken as 21 mm).

$M$  = mass of golf ball (taken as 40 g).

$m$  = slope of line of sight from golfer's eye to ball (taken as 2.5).

$r$  = radius of ring of bristles (varying from 2.5 mm to 12.5 mm).

$h$  = length of portion of bristles hidden from golfer's view (in mm).

$w$  = horizontal wind force required to dislodge ball from tee.

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The formulae for the last two variables are:

$$h = a\sqrt{m^2 + 1} - \sqrt{a^2 - r^2} - rm \quad \text{and} \quad w = \frac{Mr}{\sqrt{a^2 - r^2}}.$$

The resulting values for the lengths ( $h$ ) of the hidden portion of the bristles and the horizontal wind forces ( $w$ ) required to dislodge the ball are tabulated below, for bristle ring diameters ( $2r$ ) ranging from 5 mm to 25 mm.

Diameter $2r$	5 mm	10 mm	15 mm	20 mm	25 mm
Hidden length $h$	29.4 mm	23.6 mm	18.2 mm	13.1 mm	8.4 mm
Wind force $w$	4.8 g	9.8 g	15.3 g	21.7 g	29.6 g.

It is clear that if the bristle ring diameter is too large, then the hidden length is too short, and the visible bristles will be distracting for the golfer addressing the ball. If the ring diameter is too small, then the ball will not be sufficiently stable on the tee, and will easily be dislodged by light winds. A middle way is therefore essential for an effective design.

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